# NOTES ON BOMBIDAE, AND ON THE LIFE HISTORY OF BOMBUS AURICOMUS ROBT.

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Up to the present, little work has been done on the life-history of our American *Bombidæ*. Mr. F. W. L. Sladen, in his admirable book, "The Humble-bee," has given us, however, the principal facts in the life-history of the common English *Bombidæ*, besides many other observations of importance and interest.

There are several reasons to account for the dearth of literature on the subject of the life-history of bumblebees. Unlike the honey bee, all the individuals of *Bombus*, with the exception of the new queens, die in fall. The new queens hibernate throughout the winter in various situations, and issue forth in spring, to start new colonies. In order to obtain a good, clear, and accurate account of the life-history of *Bombus*, constant observations must be made, from a very early date in the history of the colony.

In spring, the nests of *Bombus* are less likely to be found than later in the season. This is mainly due to the fact that the nests are then smaller, and contain fewer bumblebees to attract attention. Many of the nests of *Bombus*, mentioned in the literature, were found and opened in late summer or fall. The opening of a nest in the late summer or fall permits only of observations regarding the size of the colony, the number of bumblebees of each caste present, the number of eggs, larvæ, pupæ, arrangement of the comb, and various other miscellaneous notes. The attempt to transfer a nest in spring or early summer from the field to an observation box, and to carry on a series of observations, is very apt to cause the queen to abandon her nest. In April, 1910, I found many *Bombus* queens of various species, occupying old, deserted nests of field mice. These nests were in an old pasture on the surface of the ground. No adults had as yet emerged in any of the nests examined, the nests containing eggs or small larvæ, or both. Not one of these nests was transferred to an observation box with success; the queen either deserting the nest after several days, or if confined,

dying within a short time. During the spring of 1916, however, I managed to transfer successfully young colonies of *B. pennsylvanicus* DeGeer from their original quarters to observation boxes.

### Attracting Queens to Artificial Nests.

Mr. F. W. L. Sladen found that by burying various types of domiciles in the ground in spring, he could attract *Bombus* queens and get them to nest. This enabled Sladen to get the colony at its very inception, and then by carefully removing the nest to an especially constructed bumblebee-house, the life-history could be successfully studied.

In the spring of 1915, I tried Sladen's method, using a domicile of my own design, and had the satisfaction of finding that one of my domiciles had been selected by a queen of *B. pennsylvanicus*. This queen, however, deserted the domicile because of excessive moisture. In April, 1916, I tried the experiment again, using a slightly different type of domicile, and was more successful than before.

In one domicile, which I had placed in a clay embankment, beside a railway track, and near open woods, a queen of *Bombus auricomus* Robt. started her nest. This domicile was placed in the ground on April 15, 1916, and was observed to be occupied on June 24, 1916. On the last-mentioned date, the nest was removed to an especially constructed observation box for bumblebee nests. This nest contained, when first found, the following: nine eggs, three large larvæ, five pupæ in various phases of development, one medium-sized worker, and the mother queen. Judging from the silvery, moist, and matted appearance of the worker, the worker had only recently emerged. In addition the nest contained one empty cocoon in the center of the group of cells, and a wax-pollen honey-pot. This honey-pot was separate from the remainder of the comb and was near the entrance of the nest. The queen, at this period in the history of the colony, still retained her glossy, slick, well-kept appearance of youth.

### Egg-Laying Habits of *B. auricomus*.

One of the striking habits of *B. auricomus*, noticeable at the very outset of study, was that each egg was deposited in a separate egg cell. Such a characteristic has, to my knowledge, not

heretofore been found in any species of *Bombus*. During the time that this colony of *B. auricomus* was under my observation, no eggs laid by the queen were ever deposited in batches in a single wax-pollen mass, but always in separate cells. These egg cells, or chambers, were constructed by the queen usually about twelve hours before the eggs were laid. Occasionally an egg cell was constructed, and then allowed to stand empty for several days. The queen usually laid several eggs within a period of twenty-four hours; occasionally laying more, and sometimes not laying any eggs for several days at a time. Eggs laid within a short interval of each other, were deposited in egg cells adjoining one another; thus giving the adjacent egg cells somewhat the appearance of an egg mass, but always spread out over a larger area on the surface of the comb. The place selected by the queen on which to construct her egg cells, was usually on one side, near the top of a newly spun cocoon; or in the depressed area formed between the tops of adjoining cocoons.

I have never seen a worker of *B. auricomus* making an egg cell, though there seems to be no reason why an egg-laying worker should not do so. On July 28, the mother queen was lost from the nest; her loss being traceable to the fact that she fell from the ledge at the entrance of her nest, and as her wings were clipped, could not return. For several days after the old queen disappeared from the nest, the workers were abnormally irritable, frequently biting one another, or chasing one another over the comb. On July 31, several new, empty, separate egg cells were found; and on August 2, these cells contained eggs. These last-mentioned eggs and egg cells were undoubtedly made by egg-laying workers. The stimulus that leads to the construction of an egg cell, is probably the same in both workers and queen. This stimulus is possibly due to the presence of a ripe egg in the ovaries.

On June 26, the queen laid five eggs, which is the largest number of eggs she ever laid during a single day of which I have any record. Before the queen was lost, and after the nest was transferred, she had laid thirty-seven eggs. To this total of thirty-seven eggs must be added the number of eggs, larvæ, pupæ and adults in the nest at the time the nest was taken, thus making forty-five eggs in all. The eggs are three and one-

half millimeters long and one millimeter wide; are white, sub-crescentic, tapering somewhat at one end, with both ends rounded.

### General Notes on *B. auricomus*.

Within a short time after the nest had been transferred to the observation box, the queen and worker seemed to be entirely at ease, and performed their duties as if nothing had happened. Food, consisting of a mixture of honey and water, was supplied to the queen and worker in small tin containers for several days after the transference of the nest. Feeding was necessary because the bumblebees were not allowed their freedom for several days after transference.

During the early stages of the history of the colony, the queen and solitary worker applied themselves industriously to their work. Just how the queen laid her first eggs, and cared for her first brood, I was unable to observe, as the nest was not taken in time; but the procedure probably does not differ essentially from that followed at a later date. The queen and her worker devoted much of their time to the tasks of feeding the larvæ, and of brooding over the comb, especially that part containing the egg cells. While brooding over the comb, the queen frequently and intermittently made a loud purring noise, accompanied by a sharp twitching of the wings. This purring of the queen could frequently be heard almost sixteen feet from the nest. On June 28, two more workers, both somewhat larger than the first worker, emerged within twelve hours of each other. On July 7, there were eight workers in the nest, all of which had emerged about a day or so apart. Such an irregularity in the rate of emergence of the first few workers, tends to support my belief that the first eggs laid by the queen of this species are laid separately, and at different intervals; instead of several eggs being laid at the same time in one batch.

In order to examine the eggs and young larvæ, the queen and workers were often removed from the nest, and then later returned. If one tried to open a cell while the queen or workers were around, the bumblebees would attack the forceps used in the operation, and bite them with their mandibles. Again, the bumblebees would cover over the cells, almost as fast as I could pry off the coverings without danger to the cell contents.

Every morning for about two weeks, I found that it was necessary, in order to see the contents of the nest, to remove a covering of grass, compactly held together by means of a mixture of pollen and wax. This grass covering, or roof, made by the bees naturally serves to keep light from entering the nest, for general protection, and as an aid in keeping the temperature within the nest constant.

### The Egg Stage of *B. auricomus.*

From this colony of *B. auricomus*, drones, workers, and queens were reared, under observation, from the egg to the adult stage. My notes show that the number of days in each stage of development, in all three castes, is subject to variation. Nutrition and temperature undoubtedly play a very important part in the lengthening or shortening of the various stages. The egg period varied from four to six days. No special, consistent variation in the duration of the egg stage of the three castes was noticeable, but additional data may prove the contrary. Mr. F. W. L. Sladen found that, as in the case of the honeybee, eggs laid by workers produced drones. I was unable to find out what finally happened to the worker eggs in this nest, but I am sure that if the eggs ever hatched into larvæ, these larvæ never reached the adult stage, on account of the lack of food. As already stated, the eggs laid within short intervals of each other, were laid in separate, adjoining cells, and these cells were spread out over the cocoon or cocoons as a single, more or less flattened mass. From the same egg mass all three castes frequently emerged.

### The Larval Stage of *B. auricomus.*

The larval stages of all three castes also present striking variations in duration. The average number of days spent in the larval stage for the three castes in this nest was as follows: drone, eleven and three-fourths; worker, thirteen and a fraction; queen, eleven and a fraction. Too few bumblebees of all castes were carried through from the egg to the adult stage to enable me to say that there is an average difference in the number of days spent by the three castes in the larval stage. The larvæ grow rapidly, and usually after four days or more, spin silken threads. As these silken threads hold together the thin walls of their cells, they are essential to the existence of the larvæ.

Any eggs or larvæ which may fall from their cells to the lower combs or floor of the nest, are carried out of the nest by the workers. The larvæ are fed on pollen and a fluid prepared by the queen and workers. Mr. Sladen (*The Humble-bee*, p. 28) says that this liquid food is a mixture of honey and pollen. In cells containing larvæ more than half-grown, a small hole is visible in the top of the cell. Through this opening, which is often the size of a common pin-head, the rapidly growing larvæ are fed. After a larva has just been fed, by pulling back the upper covering of the cell, one can see the liquid food injected by the queen or worker. This liquid food is often deposited in the hollow formed in the center of the curled larva, the larva of this species at this stage of development resting on one side. Before changing to a pupa, however, the larva assumes an upright position; the head end, which is at the top of the cocoon, being bent over and downward. Dwarf adults are, at least in many cases, the result of improper feeding, due to a bad position in the comb. Whether the workers and queens are the results of special feeding, as in the case of the honey bee, I am unable at present to say. The full grown larvæ of *B. auricomus* average 26 mm. in length and 6 mm. in width. The larva has a delicate, white skin, and presents in general, except in being much larger, the appearance of the larva of the honey bee. The fully grown larva spins its cocoon about three days before pupation.

After the cocoon is spun, the wax and pollen still clinging to it are removed by the workers or queen. The size of the cocoon enables one, in many instances, to separate the cocoons of the various castes from one another. The cocoons are light yellowish brown in color; thin-walled, and lack somewhat the toughness of the cocoons of *B. pennsylvanicus*. The following is a table of measurements of the cocoons of all three castes.

LARGEST COCOON.

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|---|---|
| Drone | 13 mm. wide and 19 mm. high. |
| Worker | 12 mm. wide and 15 mm. high. |
| Queen | 15 mm. wide and 23 mm. high. |

SMALLEST COCOON.

| | |
|---|---|
| Drone | 11 mm. wide and 17 mm. high. |
| Worker | 7 mm. wide and 13 mm. high. |
| Queen | 13 mm. wide and 21 mm. high. |

AVERAGE COCOON.

| | |
|---|---|
| Drone | 12 plus mm. wide and 18 plus mm. high. |
| Worker | 9 plus mm. wide and 14½ plus mm. high. |
| Queen | 13½ plus mm. wide and 22 plus mm. high. |

The pupal stage also presents variations in length. The average time spent by the three castes, in the pupal stage, was as follows: drone, nine and a fraction days; worker, nine and one-half days; queen, eleven days.

### The Adult Stage of *B. auricomus*.

When the adult is ready to emerge, a slight movement within the cocoon is noticeable. An adult escapes from its cocoon by cutting around the cap of the cocoon and pushing up the lid thus formed. Frequently, the emerging adult is assisted in escaping from its cocoon by a worker or the queen. Immediately after emerging, the adult makes a search for the nearest supply of honey. A newly emerged bumblebee has a moist, matted, velvety appearance. That portion of the pubescence which is black in the older adults of this species, is in the young adults light gray, occasionally approaching a dark brick-red; those portions which are yellow in the older adult, being very pale, almost white, in the freshly emerged specimens. Adults seldom leave the nest until their pubescence has reached its normal color.

The first adult bumblebee to emerge is probably always a worker; at least in this nest, such was the case. The second worker emerged on June 26, the first drone on July 22, and the first queen on July 24. The drones of *auricomus* appear early in the season as compared with those of most other bumblebees.

### Storage of Pollen and Honey.

For the first few days after emerging, the workers brood over the eggs, attend to the wants of the larvæ, clean out empty cocoons, and perform all those miscellaneous duties involved in a social type of existence. After that, besides helping within the nest, the workers usually leave the nest in search of pollen and nectar. On returning from a successful foraging trip, the honey is regurgitated either into the original honey-pot, or into empty cocoons used for the same purpose. Cocoons used for the storage of honey are capped over with wax. The pollen is scraped from the corbicula into empty cocoons used for that purpose. Before a worker scrapes off her load of pollen, she pokes her head into various empty cocoons, until she finds the right one for her purpose. After the pollen-containing cocoon has been found, the worker stands on the edge, facing away

from the cocoon, and inserts her hind legs down into the cocoon; then she proceeds by a quick, slicing, downward movement of the middle pair of legs, to remove the pollen from the corbicula. The spur on the end of the middle tibia probably serves as a lever to remove the pollen from the pollen-plate. The habit of storing pollen in empty cocoons away from the larval mass, would cause this species of *Bombus* to be classed as a "pollen-storer" by Sladen (Ent. Mon. Mag. 1899, p. 230). The pollen pellets once deposited, are then packed down by the same worker or by other workers; the head and mandibles being used in this operation.

### Manipulation of Wax.

Wax is produced by the females between the basal abdominal segments as Sladen also found. The color of the pure wax is white. The wax is scraped from the dorsal parts of the abdominal segments by the hind legs, which are drawn down and over the abdomen; the inner sides of the hind metatarsi serving as brushes. After the hind legs have been drawn over the dorsum of the abdomen, the bumblebee stands on her fore- and middle-legs and rubs the inner surfaces of the hind tarsi together with an up and down motion. This rubbing of the inner surfaces of the hind tarsi removes the particles of wax, which fall down on the comb. Many times I have watched bumblebees scrape the wax from their tarsi in the manner described, and have never seen one select any particular spot for depositing it. It may be mentioned, however, that the wax is usually removed while the worker or queen is standing on the brood or egg cells. The particles of wax, after being dropped, are later usually picked up by other bumblebees and worked into the surrounding comb. Wax was produced in large quantities by the old queen, but I never found signs of wax on the new queens. Wax was never noticed on the workers until after the normal color of the pubescence had been assumed.

One queer feature of this nest was the addition of a number of cells similar in structure to the original honey-pot, and attached to the latter. On July 7, eight other cells had been added to the original honey-pot, making nine in all. Later some of these cells were destroyed by the workers, and the material transferred to another part of the comb. Of these nine cells, six were not used for any purpose, pollen was stored in one,

and honey kept in two others. The original honey-pot measured on July 3, twenty millimeters in height and seventeen millimeters in width.

### Habits of the Drones and Queens.

The drones, besides fertilizing the queens, do not contribute much to the welfare of the colony. After emerging, the drone of this species stays in the nest for several days; then flies out, sometimes returning and sometimes not. While in the nest the drones are very alert, and always retreat to the bottom of the nest at the first alarm. On several occasions I have seen the drones assist in brooding over egg and larval cells. The males of *B. auricomus* have very large eyes which, together with several other characteristics, caused this species, along with others, to be placed by Robertson in a new genus *Bombias*. (Trans. Amer. Ent. Soc. Vol. 29, 1903, pp. 176, 177.) Dr. H. J. Franklin, however, does not accept *Bombias* as a valid genus, regarding it instead as a subgenus. (*Bombidæ of the New World*. Trans. Amer. Ent. Soc., Vol. 38, 1913, p. 410.) I have seen the drones of this species hovering for hours about a particular fence-post in the sun, and from there darting out from time to time. On one occasion, I tried for two successive days to catch a male of this species which persisted in alighting on a particularly high weed in a sunny situation, and was at length successful. Here also, it may be mentioned that *B. separatus* Cress., another member of the subgenus *Bombias*, with large eyes, has the same habit of selecting fence-posts, trees, and other prominent objects, and remaining about them for many hours. I have never seen a male of *B. auricomus* attempt to copulate with a queen in the same nest.

The new queens assist in the general work of the nest, and seem to get along very well together. The queens are probably fertilized by the males after leaving the nest. Hibernation of the young fertilized queens undoubtedly occurs, but I have never found a hibernating queen of this species, nor do I know of one having been found.

### Remarks on Habits.

Of the several species of *Bombus* with which I have been working, *B. auricomus* has the smallest colony, is the most easily handled, and is the most cleanly in its habits. The fæces are

always deposited either outside the observation box, or in a far corner of the nest. When examining the comb in the observation box, I frequently removed all the glass covers, without danger of alarming the inmates or of being attacked by them. Of course, if one were to breathe into, or jar the nest, the workers would be aroused to action. It was evident that this species could be bullied by another species of *Bombus*, when one morning I discovered a worker of *B. pennsylvanicus* running about on the comb of this *B. auricomus* nest, and helping herself to honey. The *auricomus* workers were aware of the presence of this alien bumblebee, but acted as if afraid to attack the invader. On the other hand, when a worker of *auricomus* is introduced into a nest of *pennsylvanicus* it is immediately attacked and killed.

*B. auricomus* is probably victimized by most of the common parasites of bumblebees, but whether any species of *Psithyrus* infest the nests I am unable to state. One worker, which I found dead on the floor of the nest one morning, contained a full grown larva of Conopidæ, *Zodion obliquefasciatum* Macq. in her abdomen. Mites of the family *Gamasidæ* were also found in the nests.

In central Illinois, *B. auricomus* is not a very common species of bumblebee.

## EXPLANATION OF PLATES.

### Plate XXIII.

Fig. 1. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, queen; *b*, workers; *c*, original honey pot. Reduced.

Fig. 2. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, queen; leaving the nest; *b*, worker brooding on egg cells; *c*, cocoon full of honey, partly capped with wax; *d*, first empty cocoon, containing pollen; *e*, empty egg cell. Reduced.

### Plate XXIV.

Fig. 3. View of the nest of *B. auricomus* Robt. on June 27, 1916, showing: *a*, empty cocoon from which first worker emerged; *b*, original honey-pot; *c*, wax-covered cocoon; *d*, small brood cells. Natural size.

Fig. 4. View of the nest of *B. auricomus* Robt. on July 7, 1916, showing: *a*, first empty cocoon; *b*, brood mass, containing medium-sized larvae in separate cells; *c*, cocoon full of honey, partly capped with wax; d, original honey-pot; *e*, extra cells added to original honey-pot; *f*, wax-covered cocoons. Natural size.